American Journal of Infectious Diseases

Original Research Paper

Seroprevalence of SARS-CoV-2 Antibodies and Associated Factors Among Health Care Workers at the Departmental and Teaching Hospital of Borgou (Republic of Benin) in 2022

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Article history
Received: 28-01-2023
Revised: 01-04-2023
Accepted: 06-04-2023

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Abstract: COVID-19 is a contagious viral infection, responsible for a pandemic that started in China in December 2019. Health Care Workers (HCWs) have been particularly exposed to this virus. The aim of this study was to estimate the seroprevalence of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) antibodies and predictors among health care workers at the Departmental and Teaching Hospital of Borgou (DTH-B). This was a descriptive and analytical cross-sectional study conducted from June 27 to July 27, 2022. Participants were recruited using a simple random draw from the list of HCWs in each hospital department. All participants gave free and informed oral consent to participate in the survey. A pre-established questionnaire was used to collect epidemiological and clinical data. Each participant received a rapid screening test for SARS-CoV-2 antibodies (Immunoglobulin [Ig] G and M). STATA/MP 14.1 software was used for data analysis. A total of 139 HCWs participated in the survey. The sex ratio was 0.51 and the mean age was 40.48±9.12 years. The SARS-CoV-2 antibodies seroprevalence was 92.02%. Eighty-six participants (63.70%) had received a complete COVID-19 vaccination and 135 (97.12%) had received at least one dose of one of the available COVID-19 vaccines in Benin. A history of confirmed COVID-19 was recorded in 31 participants (22.30%). Hospital exposure of confirmed COVID-19 cases was noted in 104 (74.82%) participants. Family exposure was noted in 18 (12.95%) participants. Factors significantly associated with SARS-CoV-2 antibodies positivity in multivariate analysis were female gender ($p = 0.001$) and complete vaccination against COVID-19 ($p = 0.002$). The SARS-CoV-2 antibodies seroprevalence among HCWs was as high as the vaccination coverage in the departmental and teaching hospital at Borgou. It would reflect the joint effect of significant exposure to the virus and the effectiveness of the COVID-19 vaccines.

Keywords: SARS-CoV-2, Antibodies, Seroprevalence, Health Care Workers, Borgou, Benin

Introduction

On March 11, 2020, the World Health Organization (WHO) declared the start of a global pandemic (WHO, 2020). It is the infection with the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) named COVID-19 (WHO, 2019). As of January 13, 2023, 662 million confirmed cases and nearly 6.7 million deaths have been reported worldwide (WHO, 2023). This pandemic started on the African continent on February 14, 2020 in Egypt (Gaye *et al*., 2021). Since the first case was reported in Benin on 16 March 2019, the cumulative toll published by the government of Benin on January 15, 2023 is 27,992 confirmed cases and 163 deaths (GRB, 2018). It has put a strain on all health systems, including in high income countries, due to high morbidity and

Science Publications

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mortality rates, forcing each health care system in affected countries to adapt rapidly (Armocida *et al*., 2020). It has been observed that many inpatient and outpatient services dedicated to other diseases have slowed down. This is the consequence of the saturation of hospitals, the contamination of personnel and the redirection of human and financial resources to the management of COVID-19.

Health Care Workers (HCWs) on the front line of the response are faced with an enormous workload due to the increase in hospitalizations and the limited capacity of health facilities to manage patients (Erdem and Lucey, 2021). They are thus inevitably exposed to the virus and are two to three times more likely to be infected than the general population (Dubost *et al*., 2020; Amnesty International, 2023). In a recent study, Amnesty International estimated that more than 7,000 HCWs have died from COVID-19 (Amnesty International, 2023).

In Benin, several measures have been taken in all hospitals in the country to limit the spread of the virus. This is the case of the Departmental and Teaching Hospital of Borgou (DTH-Borgou), a reference hospital in northern Benin. These included systematic screening of all new admissions, screening by Polymerase Chain Reaction (PCR) of all suspected cases, both among hospitalized patients and new admissions, as well as among HCWs, whether symptomatic or not, the provision of personal protective equipment to HCWs and the requirement that all hospital users wear masks. Other measures such as physical distancing, hand hygiene, education of hospital users and the general population whose effectiveness has been demonstrated in India through mathematical models have also been deployed (Gupta and Kanu, 2020; Gupta *et al*., 2020). In spite of all these measures, many cases of COVID-19 were identified among the HCWs of the departmental and teaching hospital of Borgou. This would indicate that the virus has spread widely within this hospital.

Due to international collaboration, several vaccines against COVID-19 have been developed. Benin, through the COVAX facility, received its first doses on March 10, 2021 and made vaccination of HCWs against COVID-19 mandatory by a decision taken by the council of ministers on September 1st 2021 (GRB, 2018).

It is in this context that the present study was initiated and aimed to assess the seroprevalence of SARS-CoV-2 antibodies among HCWs of the DTH-Borgou and to identify the associated factors.

Population and Methods

Type of Study

This was a descriptive and analytical cross-sectional study conducted from June 27 to July 27, 2022.

Study Population

The study population consisted of all HCWs on duty at DTH-Borgou.

Selection Criteria

Health care workers of all categories, on duty at the DTH-Borgou during the study period, who gave their free and informed oral consent to participate in the survey, were included. Any HCW who interrupted the survey for any reason were excluded.

Study Variables

The dependent variable of the study was the result of the SARS-CoV-2 rapid diagnostic test (BIOSYNEX COVID-19 BSS). This test detects IgM or IgG. The test is positive when IgG and/or IgM are positive and negative when both IgG and IgM are negative.

Considered as independent variables were sociodemographic, COVID-19 history, COVID-19 vaccination variables, exposures (hospital, family and community), lifestyle and comorbidities.

Sample Size Estimation

The minimum sample size was calculated using the Schwartz formula as follows.

The minimum size of our sample was calculated by the Schwartz formula.

With:

n = Sample size
p = The seroprevalence of SARS-CoV-2 among nursing staff in a university hospital in Turkey was determined to be 7.4% (Omrane *et al*., 2021)
q = (1-p)
$Z\alpha$ = 1.96
i = 5% (Desired accuracy)
n = [1.2 × (1.96)2 × 0.074(1-0.074)]/[0.05]2
n = 126 individuals. With a 10% increase; a minimum of 139 individuals are expected for this study

Sampling Technique

This was a random sample. Subjects were randomly recruited from all hospital wards from the HCWs rosters with weighting based on the size of the nursing staff in each ward.

The list of HCWs by category for each department was obtained from the DTH-Borgou human resources department. Then a rule of three was applied to determine the minimum number of staff x_x to be recruited per department. The lists of all categories of HCWs per department who met the inclusion criteria were then drawn up in alphabetical order and numbered from the first to the last. We proceeded to a random draw without discount from each list using small paper coupons on which these numbers are written. Once the list of personnel to be surveyed by service was known, a daily schedule was

established, taking into account the days of on call and duty of each subject to be surveyed. We then approached them to investigate them. In case of unavailability, or non-consent of a subject retained for the survey, a new random draw without discount was again carried out to replace the latter.

Initially, we obtained a list of healthcare worker by category for each department from the CHUD-B/A human resources department.

Application of the rule of three to determine the minimum staffing x_x to be recruited per department.

Or:

A = Sample size (n)
EX = X_X (?)

with:

EX = The number of healthcare personnel meeting the inclusion criteria by hospital department
A = Total of all healthcare worker meeting the inclusion criteria of the different departments involved in this study
Xx = Minimum size of staff to be recruited per department
n = 139 represents the sample size for this study calculated according to the Schwartz formula where
Xx = $(Ex * n)/A$

Table 1 shows the summary of the results of the sampling technique, specifying the number of participants per department.

Data Collection

Data were collected during a face-to-face interview using a pre-designed questionnaire. The pre-test of the tools was done before starting the survey. Data collection was carried out in two stages. In the first stage, with the oral and informed consent of each participant, the interview allowed the variables defined above to be filled in. In the second stage, the rapid screening test for SARS-CoV-2 was performed, looking for immunoglobulin G (IgG) and/or M (IgM).

Validation of the Serological Test

The BIOSYNEX COVID-19 BSS (IgM/IgG) rapid test was performed in this study to determine the presence of SARS-CoV-2 antibodies in the respondents. According to the manufacturer, the IgG sensitivity of the test was 100% and the IgG specificity was 99.5%. The IgM sensitivity of the test was 92.6% and the IgM specificity was 99.2% (BIOSYNEX, 2023).

A compared study of five new SARS-CoV-2 whole blood finger stick IgG/IgM combined RDTs found a sensitivity of 95.8% and a specificity of 98.1% for BIOSYNEX COVID-19 BSS (IgG/IgM) test (Péré *et al*., 2021). In addition, a study found that after 15 days after symptom onset, BIOSYNEX test combining IgM and IgG detection showed the best performances (Velay *et al*., 2020). Thus, the test used in this study provides an assessment of the respondents SARS-CoV-2 antibodies seroprevalence.

Data Analysis

At the end of the data collection, the forms were manually analyzed to verify the completeness and consistency of the data. Data was entered twice in the French version of epi data 3.1. The data were cleaned and analyzed using the STATA/MP 14.1 statistical software. A descriptive analysis of the variables under study was performed. Thus, for the qualitative variables, the frequencies and proportions were determined. Comparisons were made using the Chi2 test or exact test if the expected value is less than 5. For the quantitative ones, the means with their standard deviation, medians, minima and maxima were described. To determine the associated factors, the logistic regression model in bivariate and multivariate analysis was used. This provided measures of associations, Odds Ratios (ORs) and their confidence intervals, p-values associated with Wald chi2. The threshold of significance was 5% and confidence intervals were calculated at 95%.

Table 1: Summary of the results of the sampling technique, specifying the number of participants per department

	Department	Ex = size (healthcare worker)	X_x = minimum number of agents to recruit with $X_x = (Ex*n)/A$	Percentage $P_x = (X_x *100)/n$
1.	Internal medicine and neurology	$E_1 = 31$	$X_1 = 12$	$P_1 = 8.63$
2.	Psychiatry	$E_2 = 06$	$X_2 = 2$	$P_2 = 1.44$
3.	Nephrology	$E_3 = 06$	$X_3 = 2$	$P_3 = 1.44$
4.	Cardiology	$E_4 = 11$	$X_4 = 5$	$P_4 = 3.60$
5.	Dermatology	$E_5 = 7$	$X_5 = 3$	$P_5 = 2.16$
6.	Physiotherapy	$E_6 = 7$	$X_6 = 3$	$P_6 = 2.16$
7.	Surgery: Inpatient + block	$E_7 = 38$	$X_7 = 16$	$P_7 = 11.51$
8.	Ophthalmology	$E_8 = 6$	$X_8 = 3$	$P_8 = 2.16$
9.	Stomatology	$E_9 = 4$	$X_9 = 2$	$P_9 = 1.44$
10.	ENT	$E_{10} = 16$	$X_{10} = 7$	$P_{10} = 5.03$
11.	SARU	$E_{11} = 43$	$X_{11} = 16$	$P_{11} = 11.51$
12.	Laboratory	$E_{12} = 27$	$X_{12} = 11$	$P_{12} = 7.91$
13.	Radiology	$E_{13} = 13$	$X_{13} = 5$	$P_{13} = 3.6$
14.	Pediatrics	$E_{14} = 54$	$X_{14} = 22$	$P_{14} = 15.83$
15.	Obstetrical gynecology	$E_{15} = 75$	$X_{15} = 30$	$P_{15} = 21.58$
Totals:		A = 344	n = 139	100%

Ethical Considerations and Good Practices

Ethical approval was obtained from the biomedical research ethical committee of the University of Parakou (CLERB). The data were treated confidentially and anonymously.

Results

A total of 139 health care workers were surveyed (Fig. 1).

Socio-Demographic Characteristics of Participants

Participants mean age was 40.48±9.12 years and the sex ratio were 0.51. Nurses represented 46.76% followed by nursing auxiliary (17.27%). In terms of the hospital department, 40 (28.78%) participants worked in internal medicine and 28 (20.14%) in surgery. Table 2 presents participants general characteristics.

History of COVID-19

Of the 139 participants, 104 (74.82%) had been contacts of confirmed COVID-19 cases in the hospital setting and 18 (12.95%) had family exposure. Thirty-one participants (22.30%) had experienced a confirmed COVID-19. Of these, 29 (93.55%) had had the disease more than 6 months before the day of the survey. More than two thirds (80.65%) of the participants with confirmed COVID-19 reported having had the disease before vaccination. Four participants (12.90%) had COVID-19 after their vaccination. Table 3 presents participants exposure and history of COVID-19 data.

Table 2: General characteristics of health care workers surveyed at DTH-Borgou in 2022

	Numbers	%
Age (N = 139)		
<50 years	119	85.61
≥50 years	20	14.39
Gender (N = 139)		
Female	92	66.19
Male	47	33.81
Participants' hospital department (N = 139)		
Medicine and medical specialties	40	28.78
Surgery and surgical specialties	28	20.14
Gynecology and pediatrics	52	37.41
Laboratory and medical imaging	19	13.67
Occupation (N = 139)		
Nurse	65	46.76
Nursing auxiliary	24	17.27
Physician	19	13.67
Midwife	11	7.91
Laboratory technician	10	7.19
Imaging technician	6	4.32
Physiotherapist	4	2.88
Marital status (N = 139)		
In couple	117	84.17
Single	22	15.83
Level of education (N = 139)		
Primary	10	7.19
Secondary	65	46.76
University	64	46.04
Graduation (N = 139)		
Certificate of end primary school	16	11.51
Certificate of end secondary school	48	34.53
Baccalaureate	19	13.67
License	24	17.27
Master	13	9.35
Doctorate	10	7.19
Post doctorate	9	6.47
Comorbidities (N = 139)		
No comorbidity	102	73.38
High blood pressure	18	12.95
Obesity or overweight	10	7.19
Diabetes	3	2.16
Asthma	4	2.88
Hepatitis B	1	0.72
Epilepsy	1	0.72

Table 3: Exposure and history of COVID-19 among health care workers surveyed at DTH-Borgou in 2022

	Numbers	%
Personal history of COVID-19 (N = 139)		
Yes	31	22.30
No	108	77.70
Number of COVID-19 episodes before the survey (N = 31)		
Once	25	80.65
Twice	4	12.90
Thrice	2	6.45
Moment of occurrence of COVID-19 among participants (N = 31)		
Before vaccination	25	80.65
After vaccination	4	12.90
Before and after vaccination	2	6.45
Time between last episode of COVID-19 and the survey's date (N = 31)		
<6 months	2	6.45
[6-12 months]	11	35.48
[12-18 months]	17	54.84
≥18 months	1	3.23
Source of contamination (N = 31)		
Service colleague	15	48.39
Family member	2	6.45
Community	1	3.23
Don't know	13	41.94
Family exposure to COVID-19 (N = 139)		
Yes	18	12.95
No	116	83.45
Don't know	5	3.60
Professional exposure to COVID-19 (N = 139)		
Yes	104	74.82
No	08	5.76
Don't know	27	19.42
Household size (N = 139)		
1-2 inhabitants	16	11.51
3-4 inhabitants	39	28.06
≥5 inhabitants	84	60.43

SARS-CoV-2 Vaccination Coverage Among Participants

One hundred and thirty-five participants (97.12%) had received at least one dose of vaccine, for an overall vaccination coverage rate of 97.12%. Of these, 49 or 36% had incomplete vaccination status. Vaccination took place more than six months before the survey in 131 (97.04%) participants. Vaccination was carried out by HCWs as a result of mandatory vaccination in 73% of cases and voluntary in 26% of cases. Table 4 presents participants vaccination data.

SARS-CoV-2 Antibodies Seroprevalence

The serological test was positive in 128 participants, for SARS-CoV-2 antibodies seroprevalence of 92.02%. According to vaccination status, the SARS-CoV-2 antibodies seroprevalence was 91.85% in vaccinated participants and 100% in unvaccinated participants. Figure 2 shows the participants SARS-CoV-2 serological profile.

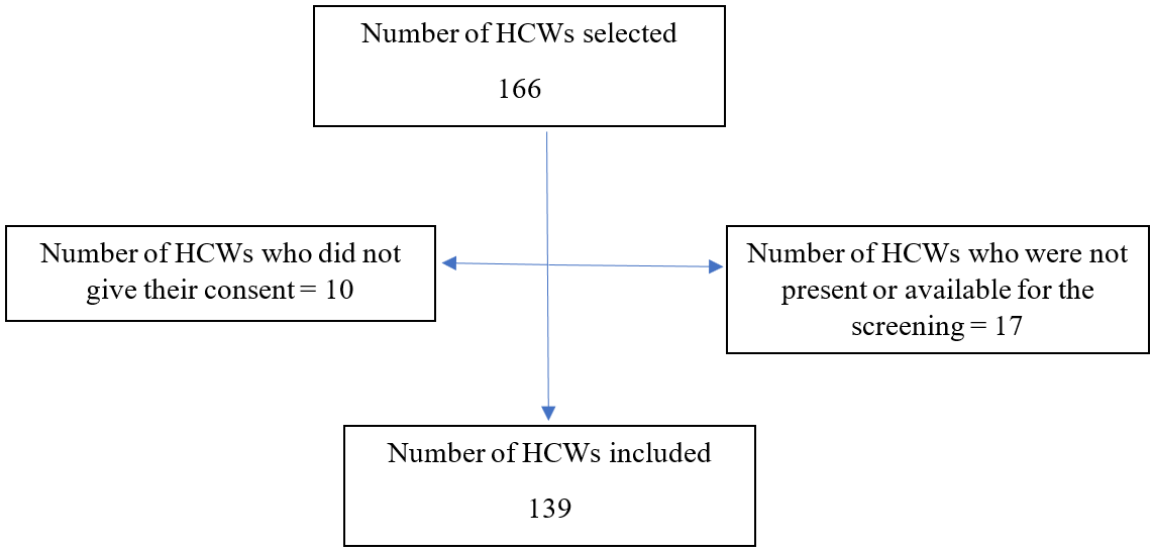

Fig. 1: Flow chart of the current investigation

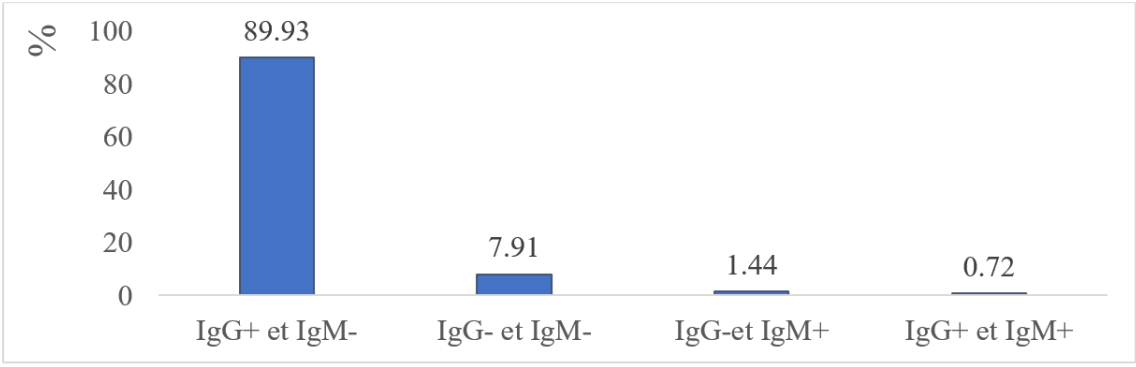

Fig. 2: SARS-CoV-2 serological profile of health care workers surveyed at DTH-Borgou in 2022

Table 4: Vaccination against COVID-19 data for health care workers surveyed at DTH-Borgou in 2022

	Numbers	%
Immunization status (N = 139)		
Vaccinated	135	97.12
Not vaccinated	4	2.88
Circumstance of vaccination (N = 135)		
Compulsory vaccination	99	73.33
Voluntary vaccination	35	25.93
Medical prescription	1	0.74

Table 4: Continue

Reasons for non-vaccination (N = 4)		
Loss of confidence in science	2	50.00
Fear of side effects	1	25.00
Influence of social networks	1	25.00
Type of vaccine (N = 135)		
Sinovac	71	52.59
Johnson and Johnson	53	39.26
Sinovac + Johnson and Johnson	4	2.96
Pfizer	3	2.22
Astra Zeneca	3	2.22
Sputnik	1	0.75
Reasons for choosing the type of vaccine		
Fewer side effects	45	33.33
Personal choice	29	21.48
Single dose	20	14.81
Advice from a health worker	16	11.85
Choice of the vaccinator agent	15	11.11
Known manufacturing method	8	5.92
Advice from a parent	2	1.48
Completeness of immunization status (N = 135)		
Complete	86	63,7.00
Incomplete	49	36.30
Time between last dose of vaccine and survey date (N = 135)		
<6 months	4	2.96
≥6 months	131	97.04
Presence of post-vaccination side effects (N = 135)		
Yes	41	30.37
No	94	69.63
Types of side effects reported (N = 41)		
Headaches	18	13.33
Fatigue	17	12.59
Fever	16	11.85
Pain at the injection site	10	7.41
Dizziness	11	8.15
Cough	3	2.22
Palpitation	3	2.22
Diarrhea	2	1.48
Vomiting	1	0.74
Dyspnea	1	0.74

Table 5: Associated factors of SARS-CoV-2 seropositivity among health care workers surveyed at DTH-Borgou in 2022 (bivariate analysis)

	SARS-CoV-2 serological status n (%)				
	N	Positive	Negative	OR [CI (95%)]	p-value[†]
Age					0.37*
<50 years	119	108(90.76)	11(9.24)	-	
≥50 years	20	20(100)	0(0)	-	
Sex					0.035
Female	92	88(95.65)	4(4.35)	3.85[1.07-13.90]	
Male	47	40(85.11)	7(14.89)	1	
Profession					0.66
Paramedical	120	111(92.50)	9(7.50)	1.45[0.29-7.30]	
Medical	19	17(89.47)	2(10.53)	1	
Marital status					0.31

Table 5: Continue

In couple	117	109(93.16)	8(6.84)	1	
Single	22	19(86.36)	3(13.64)	0.46[0.11-1.91]	
Hospital department					0.32*
Medicine and specialties	40	38(95)	2(5)	1.05(0.89-12.41)	
Surgery and specialties	28	27(96.43)	1(3.57)	1.5(0.09-25.55)	
Gynecology and pediatrics	52	45(86.54)	7(13.46)	1.36(0.41-3.11)	
Laboratory and medical imaging	19	18(94.74)	1(5.26)	1	
Level of education					0.92
Less than university level	75	69(92)	6(8)	1	
University level	64	59(92.19)	5(7.81)	1,02[0.30-3.53]	
Vaccination status					1.00*
Vaccinated	135	124(91.85)	11(8.15)	-	
Non vaccinated	4	4(100)	0(0)	-	
Completeness of immunization status					0.05
Complete	86	82(95.35)	4(4.65)	3.42[0.95-12.33]	
Incomplete	49	42(85.71)	7(14.29)	1	
Time between vaccination and survey				0.32	
< 6 months	4	3(75)	1(25)	0.14[0.01-1.97]	
[6-12 [months	85	77(90.59)	8(9.41)	0.44[0.09-2.15]	
[12-18] months	46	44(95.65)	2(4.35)	1	
Side effects					0.34
No	94	85(90.43)	9(9.57)	1	
Yes	41	39(95.12)	2(4.88)	2.06[0.42-10.00]	
Sinovac					0.05
Yes	75	66(88)	9(12)	0.25[0.05-1,22]	
No	60	58(96.67)	2(3.33)	1	
Johnson and Johnson					0.28
Yes	57	54(94.74)	3(5.26)	2.06[0.52-8.12]	
No	78	70(89.74)	8(10.26)	1	
Pfizer					1.00*
Yes	3	3(100)	0(0)	-	
No	132	121(91.67)	11(8.33)	-	
Astra Zeneca					1.00*
Yes	3	3(100)	0(0)	-	
No	132	121(91.67)	11(8.33)	-	
Sinovac + Johnson and Johnson					0.29
Yes	4	3(75)	1(25)	0.24[0.02-2.52]	
No	131	121(92.37)	10(7.63)	1	
Sputnik					1.00*
Yes	1	1(100)	0(0)	-	
No	134	123(91.79)	11(8.21)	-	
Personal history of COVID-19					0.12*
Yes	31	31(100)	0(0)	-	
No	108	97(89.81)	11(10.19)	-	
Family exposure at COVID-19					0.58*
Yes	18	18(100)	0(0)	-	
No	116	105(90.52)	11(9.48)	-	
Don't know	5	5(100)	0(0)	-	
Hospital exposure to COVID-19					0.68
Yes	104	97(93.27)	7(6.73)	1	
No	8	7(87.50)	1(12.50)	0.50(0.05-4.70)	
Don't know	27	24(88.89)	3(11.11)	0.58(0.14-2.40)	
Household size					0.24
1-2	16	14(87.50)	2(12.50)	1	
3-4	39	34(87.18)	5(12.82)	0.97(0.17-5.61)	
≥5	84	80(95.24)	4(4.76)	2.86(1.48-17.11)	

OR = Odds Ratio; CI (95%) = 95% Confidence Interval; † Wald chi-square p-value; *Fisher's exact

Table 6: Predictors of SARS-CoV-2 seropositivity among health care workers surveyed at DTH-Borgou in 2022 (multivariate analysis)

	N	Positive SARS-CoV-2 serology n (%)	Adjusted OR [CI (95%)]	p-value†
Gender				0.001
Female	92	88(95.65)	10.62 [2.18-51.64]	
Male	47	40(85.11)	1	
Completeness of immunization status				0.002
Complete	86	82(95.35)	9.51 [1.95-46.35]	
Incomplete	49	42(85.71)	1	

OR = Odds Ratio; CI (95%) = 95% Confidence Interval; † Chi-square p-value

Predictors of SARS-CoV-2 Seropositivity

In bivariate analysis, the associated factors of SARS-CoV-2 seropositivity were female gender (p = 0.035), use of Sinovac vaccine (p = 0.05) and completeness of vaccination status (p = 0.05). Age, occupation and location were not statistically significantly associated with the presence of antibodies (Table 5).

In multivariate analysis, the two predictors of SARS-CoV-2 seropositivity were female gender (Ora = 10.62 [2.18-51.64]) and complete vaccination status (Ora = 9.51 [1.95-46.35]) (Table 6).

Discussion

SARS-CoV-2 Vaccination Coverage Among Participants

Of the 139 participants, 135 had received at least one dose of one of the available COVID-19 vaccines in Benin, for an overall vaccination coverage rate of 97.12%. Vaccination coverage of HCWs varies from one setting to another depending on the vaccination policies adopted. In a systematic review of the literature, the average vaccination coverage of HCWs was 48% in West Africa (Ackah *et al*., 2022). According to CDC Atlanta, 68.2% of HCWs had received at least one dose of COVID-19 vaccine (Razzaghi *et al*., 2022). In Tunisia, coverage ranged from 55.2 (Omrane *et al*., 2022) to 83.5% (Snène *et al*., 2022) among HCWs.

The very high rate obtained in Benin is the result of compliance with the vaccination obligation imposed on this target.

SARS-CoV-2 antibodies seroprevalence among health care workers.

The seroprevalence of SARS-CoV-2 antibodies among the participants at DTH-Borgou was 92.02%. This result, which can be attributed to the high vaccination coverage, raises several questions. Only 63.7% of the participants had been fully vaccinated. The most commonly used vaccines were Sinovac, the Chinese vaccine and Johnson and Johnson. This means that the 36.3% who were partially vaccinated had in fact received only one dose of the Chinese vaccine called Sinovac. In addition, no booster vaccination was performed in Benin, contrary to what is observed in developed countries (Bert *et al*., 2022; Edwards and Orenstein, 2022). Moreover, this seroprevalence survey was conducted more than six months after the last dose of vaccine in 97.04% of the participants. All these elements suggest that the high rate of seropositivity observed among participants cannot be the exclusive consequence of good vaccine coverage. A strong and constant exposure to the virus would certainly have contributed to maintain an immunity of the participants towards SARS-CoV-2. The proof is that 100% of the non-vaccinated participants have a positive serology.

Seroprevalence varies from one study to another. It was 41.2% in Congo (Mukwege *et al*., 2021), 45.1% in Nigeria (Olayanju *et al*., 2021) and 68.1% in Mali (Somboro *et al*., 2022) among unvaccinated health care workers.

In all cases, these results show that HCWs of all categories were mainly exposed to this virus, being in the front line of the response to COVID-19. This justifies the importance of policies aimed at reinforcing the safety of health care workers through vaccination and the strengthening of infection prevention and control measures in the health care setting.

Associated Factors of SARS-CoV-2 Seropositivity

The independent associated factors of SARS-CoV-2 seropositivity in participants surveyed in Parakou were vaccine completion and female gender. Female subjects were 10 times more likely to be seropositive than male subjects (Ora = 10.62 [2.18-51.64]). The same trend was noted in a Korean study (Choi *et al*., 2022) as well as in a general population seroprevalence study conducted by public health agency in France (Aumaître *et al*., 2022). This gender difference was also found in the Epicov study in France (Warszawski *et al*., 2020). It could be explained by the fact that women would be more exposed to SARS-CoV-2 as demonstrated by a study on the inequalities between men and women in relation to COVID-19 conducted in France (Neufcourt *et al*., 2021). The role played by women in the community, which is to take care of children, the elderly, the sick and to go to the market, for example, could explain their high exposure to the virus.

As for the completeness of the SARS-CoV-2 vaccination status, it shows that it increases the chance of having a positive serology by more than 9 times (RCa = 9.51 [1.95-46.35]) than in personnel with an incomplete vaccination status. Our observations corroborate those of other authors. Indeed, in a study in

Germany, HCWs had obtained a 100% humoral response after two doses of Pfizer vaccine (Herzberg *et al*., 2022). These results support the use of vaccines to combat the COVID-19 pandemic. In the present study, a personal history of SARS-CoV-2 infection was associated with SARS-CoV-2 antibodies positivity. Indeed, in 100% of the cases, participants with a personal history of COVID-19 had positive serology of SARS-CoV-2. On the other hand, service was not associated with the presence of SARS-CoV-2 antibodies (p = 0.32). This was also found in the Malian study (Somboro *et al*., 2022). This could be due to the fact that these centers, like ours, were not exclusively dedicated to the management of patients with COVID-19. In fact, a triage system was set up in the emergency room of the DTH-Borgou, allowing patients who tested positive for SARS-CoV-2 to be referred to the epidemic management center located outside the hospital. We looked for, but did not find, an association between family and/or occupational exposure to a COVID-19 case and SARS-CoV-2 antibodies seropositivity. In a Belgian study, contact with a COVID-19-infected service colleague was not statistically associated with seropositivity. In contrast, in the same study, household contact with a COVID-19 case was associated with antibody positivity (Steensels *et al*., 2020). This was similar to the study conducted by public health agency in France, which found that the presence of intrafamilial clinical cases of COVID-19 increased the risk of being seropositive for SARS-CoV-2 with an Ora = 2.5 [1.3-5.0]) (Aumaître *et al*., 2022).

Strengths and Limitations of the Study

This study has the merit of giving a preliminary data of the SARS-CoV-2 serological profile among Beninese health care workers. It will serve as a basis for comparison in subsequent qualitative or quantitative studies.

However, the main weakness of this study remains its qualitative nature. It does not allow us to assess the degree of effective immunity of the participants. Moreover, the early start of vaccination and its imposition on health care workers did not allow us to distinguish between the spread of the virus and vaccine protection.

Conclusion

The present study found high seroprevalence among health care workers surveyed in a hospital in northern Benin. This high seroprevalence rate reflects the combined effect of high exposure to SARS-CoV-2 and COVID-19 vaccination. Further studies, especially quantitative ones, will allow a better assessment of the existence of protective immunity of the participants to this disease.

Acknowledgment

We thank all health workers who participated in this survey.

Funding Information

The authors have not received any financial support or funding to report.

Author's Contributions

Cossi Angelo Attinsounon: Coordinated the research, designed the research plan, coordinated the data collection and written the manuscript.

Alidjinou Kazali: Contributed to designed the research plan and coordinated the bloods sample analysis.

Vodounou Amos: Developed the research protocol, conducted the data collection and contributed to the written of the manuscript.

Acakpo Jocelyn: Coordinated the data analysis.

Dovonou Albert: Proofread the manuscript.

Ethics

The author does not see any ethical issues that may arise after the publication of this manuscript.

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